# GROUND WATER PLUME DELINEATION USING IN-FIELD DIRECT PUSH TECHNOLOGY

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## ABSTRACT

On site analysis of ground water is employed by NASA for the rapid and cost effective determination of the extent of migration of dissolved Volatile Organic Compounds (VOC's). Accurate plume delineation is necessary for the design of any form of remedial activity, and preliminary sampling enables site investigators to effectively locate permanent monitoring wells for further assessment. The subject study took place at a site, located in a coastal environment, where historical releases had occurred from septic tanks receiving waste from laboratories and field cleaning operations of space flight equipment. On site ground water sampling using direct push technology and analysis was performed to determine the horizontal and vertical extent of the contaminant plume. Samples were collected at various depths using a truck mounted Geoprobe (a direct push technology). The water samples were analyzed using a field gas chromatograph and the soils were logged in the field. This sampling method allows the investigator to delineate soil stratigraphy and to conduct depth specific sampling of both soils and ground water. The data collected was used to define ground water flow, determine extent of contamination and to select the locations of subsequent sampling points. The ground water and soil investigation revealed that the plume consisting of Trichloroethylene had a significant westerly component, away from the ocean. Changes in direction and contamination level of the plume have been mapped at different depths. The investigation was performed for a 3 week period and involved sampling and analysis at 49 locations. Based on this data, a 421 acre, 30-foot deep area was found to be contaminated with VOC's. The study provided an accurate delineation of the horizontal and vertical extent of ground water contamination at this site. This data will be

used to select the location of monitoring wells, thereby providing sampling points conforming to regulatory standards for analytical and hydrogeological data collection for the formal RCRA Facility Investigation.

## DESCRIPTION OF PROCESS

The Geoprobe sampling system (GSS) is a four wheel drive truck mounted direct push technology that is a hydraulically advanced stainless steel, slotted, well point that is capable of obtaining ground water samples at discreet locations in the subsurface. The well point is attached to steel rods that are each two feet long and one inch in diameter with threaded ends. The rods are screwed together at the surface and advanced to the sampling depth. Once the rod is advanced to the selected sampling depth, a Teflon tube is advanced down the interior of the rod and ground water samples are then collected by using a peristaltic pump. An alternative method of sampling is to lower a bailer down the interior of the rod to collect the ground water samples.

To sample at different depths at the same location, the Teflon sampling tube is removed, additional rods are attached and advanced into the subsurface. The sampling routine is then repeated. Sampling can be repeated at different depths at the same location, providing a vertical profile of the contamination at the site. This sampling regime, coupled with analysis by gas chromatography at a near by screening laboratory, provides the field investigator information on the extent, location, concentration and type of contamination. The field screening laboratory was used to identify site contaminants, and the analytical laboratory was informed of any high levels of contamination that may affect their equipment or dilution levels.

Additional capabilities of this sampling system are: a core sampler, capable of collecting soil samples; and soil gas sampling. The use of these GSS capabilities is an excellent method for screening soil and ground water contamination prior to the installation of monitoring or recovery wells.

Limitations to this direct push process are an increase in soil resistance to the rod limits the depth at which sampling can be conducted. The greatest sampling depth that has been conducted at this facility was to 60 feet below grade. Several other firms have developed field rigs with large amounts of weight bolted to the rig to provide a counter weight to the soil's resistance. Sampling using the KSC system is limited to areas consisting of unconsolidated sand, shell and silts.

## INITIATION OF STUDY

The Launch Complex 34 (LCX 34) site is a NASA, Kennedy Space Center, operated facility located on the Cape Canaveral Air Force Station, Brevard County, Florida.

During the maintenance of an electrical substation at the complex, a portable generator was provided to support operations. The generator piping developed a leak and released an unknown quantity of diesel fuel to the environment. While excavating the soils to remove this spill ground water entered the excavation area. This water was sampled and analyzed, results indicated the presence of solvents. An investigation of the potential sources of these solvents led to the septic systems in the area. The contents were sampled and found to have levels of trichloroethene (TCE) that exceeded Toxicity Characteristic (TCLP) levels. One septic tank system was taken out of service and cleaned, and the material in the septic tanks was disposed of as hazardous waste. A preliminary soil and ground water contamination investigation was conducted to assess the potential risk to human health.

## HISTORY OF THE SITE

Launch Complex 34 (LCX-34), Facility 21900 is located northeast of the intersection of Cape Road and ICBM Road, between LCX-20 and LCX-37 in Area 2 of Cape Canaveral Air Force Station (CCAFS). LCX-34 was built in 1959-1960 for NASA's Saturn 1 and 1B Missile Programs. LCX-34 was deactivated for launch purposes in 1968, and salvaged in 1972. The facility is currently used for office and laboratory space. A hydrocarbon recovery facility is also located within the boundaries of the complex.

A "pad flush" system was designed as part of the overall water supply and distribution system constructed at the site. The purpose of the pad flush was to wash away any fuel spilled on the launch pad. In addition, TCE engine flushes were conducted for the Saturn rockets launched from LCX-34. Engine flushes were a normal operational activity in the early years of the space program. These flushes consisted of pouring TCE through the rocket engines prior to launch to remove any build up of deposits that may have occurred.

A 30,506 square foot Operations Support Building was located west of the blockhouse (the control/firing room used in the Saturn 1 program). This facility was used for general shop and engineering activities in direct support of launch operations. Wash racks were reportedly located behind this facility. Parts and component cleaning were conducted at the wash racks. Halogenated solvents, such as TCE, carbon tetrachloride, and methylene chloride were used during the cleaning operation. Waste liquids generated at this facility were reportedly discharged on occasion to the ground surface.

Interviews with current and former NASA and Air Force personnel indicated that a TCE wash-down area existed behind the Engineering Support Building. These wash down racks were previously used to wash small equipment parts with TCE.

## SITE GEOLOGY

The surficial features on the Canaveral Peninsula barrier island are primarily composed of up to 300 sub parallel relict beach ridges. This beach ridge system has been formed during the last 6,000 years. Individual beach ridge deposits are comprised primarily of quartz sand with shell fragments.

Shallow deposits underlying the area consist of mixture of Pleistocene and Holocene beach sand deposits which extend to a depth of fifty feet or more.

Portions of the Anastasia Formation lie beneath the surficial sands; however, the formation is discontinuous and heavily weathered. The

lithology of the Anastasia Formation underneath CCAFS is characterized by cemented sand and shell conglomerates (coquina shell and sand).

The Ocala Group and Avon Park Formation limestones of Ecocene Age are located beneath the Hawthorn Formation. These formations are underlain at depth by a series of limestone formations several thousands of feet thick.

The depth to the top of the Ocala Limestone ranges from approximately 120 feet below land surface (BLS) at the Kennedy Space Center to over 200 feet at Patrick Air Force Base (PAFB), south of CCAFS. Boring log data from the deep wells at CCAFS indicate that the top of the Hawthorn Formation is located at an average depth of 110 feet BLS, and the top of the Ocala Limestone is located at an average depth of 180 feet BLS.

## HYDROGEOLOGY CONDITIONS

Ground water occurs under confined (artesian) and unconfined (nonartesian) conditions at CCAFS. The unconfined or surficial aquifer system is composed of Holocene and Pleistocene Age deposits of mostly marine sands mixed with shell fragments as well as some coquina of the Anastasia Formation. The surficial aquifer system is recharged by rainfall along the coastal ridges and dunes located on the barrier island. Little recharge to the surfical aquifer system occurs in the low, swampy area. The direction of ground water flow in the surficial aquifer system of CCAFS varies with location.

A ground water divide is generally formed along the center of the barrier island. Regional flows in this area are generally either to the East (Atlantic Ocean) or to the West (Banana River)

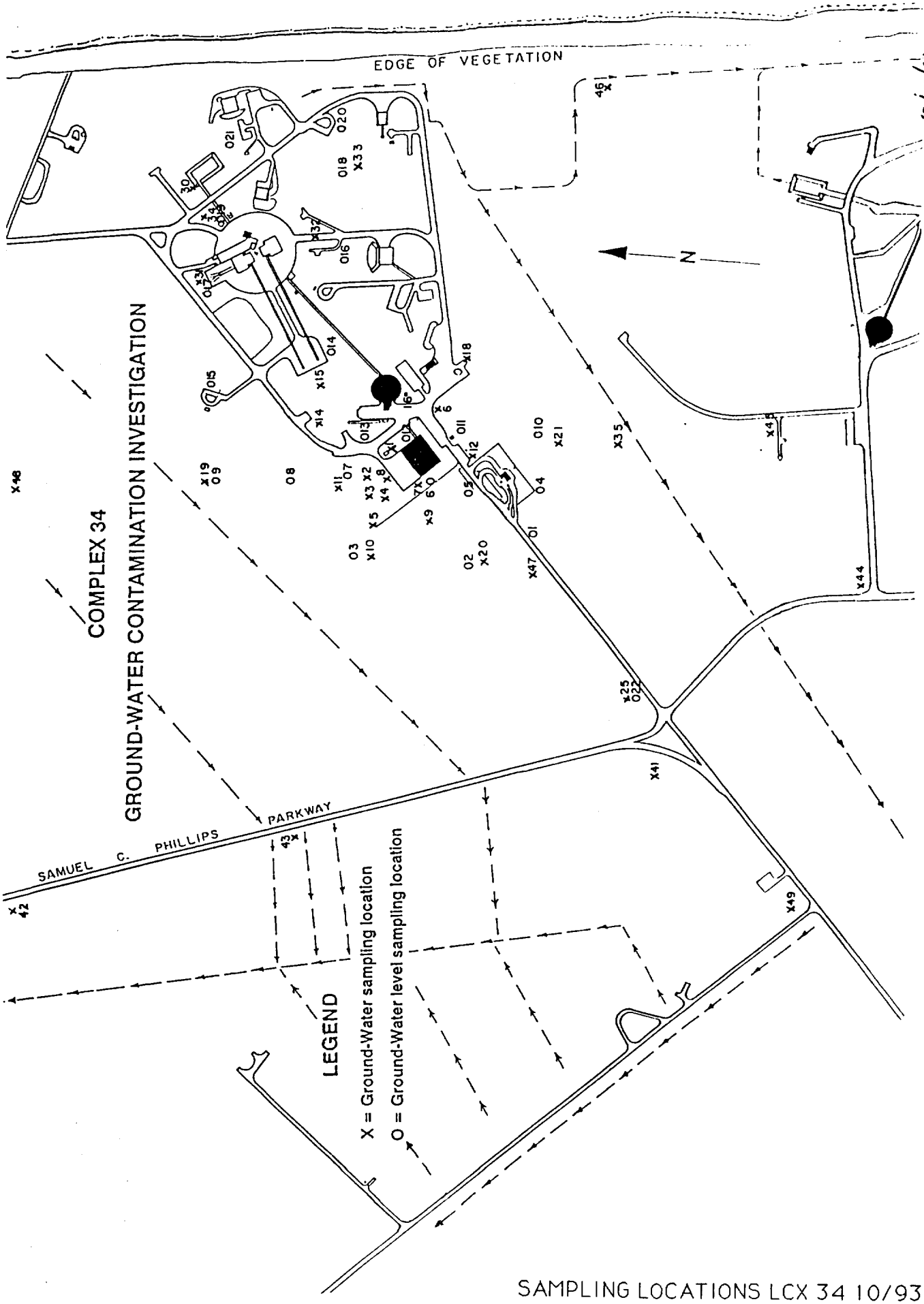
Beneath the unconfined surficial aquifer system, at a depth of approximately 30 feet BLS, is a discontinuous confining zone consisting of the Hawthorn formation, which consists primarily of clays, and acts as the confining unit to the Floridan Aquifer System. The top of the Hawthorn Formation is located at a depth of approximately 110 feet BLS at CCAFS. Below this unit is the Floridan Aquifer System, under positive

pressure in this area, thereby precluding contamination from entering this system.

## INVESTIGATION

Ground water samples were initially collected from the upper portion of the surficial aquifer system. Soil samples were collected at the surface, mid depth, and just above the soil/ground water interface. Samples were collected at five foot intervals starting from land surface to a depth of 20 feet BLS, with several of the sampling locations being advanced to a depth of 25 feet BLS. Following the review of this data, additional investigation into the extent of the contamination at Complex 34 was initiated. Ground water elevations were taken at 21 locations to map the water table and determine the direction of ground water flow. Once this was determined, additional ground water sampling locations were selected. These sampling points were located around the engineering support building, as well as in the vicinity of the launch pad and block house. The sampling locations also extended south on the Samuel Phillips Parkway approximately 1/4 mile and north along the Parkway approximately 1/2 mile. A total of 49 locations were sampled using the GSS, as well as the three monitoring wells associated with the LCX 34 Hydrocarbon Recovery Facility (HRF). All samples where taken in accordance with the KSC Base Operations Contractor Internal Operating Procedures and Comprehensive Quality Assurance Plan. Sampling analysis was performed with the portable GC at the KSC Environmental Health Field Screening Laboratory.

Figure 1 shows the LCX 34 sampling locations. The results of the site ground water sampling are shown on Table 1. As indicated on Table 1, two areas with high levels of TCE and its break down products (vinyle chloride, cis-1,2-dichloroethene and trans-1,2-dichloroethene) were found, one on the southeast side of the Engineering Support Building and the second on the east side of this building. These findings coincide with historical information collected during this investigation relative to past. The VOC contamination levels are greatest at approximately 25 feet BLS. At a depth of seven feet BLS the total VOC levels are about 7,800 parts per billion (ppb), at 10 feet BLS the VOC concentration




SAMPLING LOCATIONS LCX 34 10/93

FIGURE 1

# TABLE 1

COMPLEX 34 GROUND WATER
CONTAMINATION INVESTIGATION
ANALYTE CONCENTRATIONS, ug/L

| SITE-DEPTH | | VCHL | C12DCE | T12DCE | TCE |
|---|---|---|---|---|---|
| Septic Tank 1 | * | -- | -- | -- | 12000 |
| Septic Tank 2 | * | -- | -- | -- | -- |
| 1-07 | | <5 | 120 | <5 | <5 |
| 1-15 | | 20 | 610 | 27 | 6.8 |
| 2-07 | | <5 | 23 | <5 | <5 |
| 2-15 | | <5 | 190 | <5 | <5 |
| 3-07 | | <5 | <5 | <5 | <5 |
| 3-15 | | <5 | 32 | <5 | <5 |
| 4-07 | | <5 | 20 | <5 | <5 |
| 4-10 | | <5 | <5 | <5 | <5 |
| 4-15 | | 5.8 | 130 | <5 | <5 |
| 4-20 | | 81 | 870 | 28 | <5 |
| 4-25 | | 290 | 24800 | 280 | <5 |
| 4-30 | | 15 | 350 | <5 | <5 |
| 4-36 | | <5 | 7.8 | <5 | <5 |
| 5-07 | | <5 | 42 | <5 | <5 |
| 5-15 | | 9.3 | 290 | <5 | <5 |
| 6-07 | | 22 | 240 | 13 | <5 |
| 6-15 | * | 62 | 11000 | 820 | 7200 |
| 7-07 | | 47 | 3000 | 47 | 7800 |
| 7-15 | * | 370 | 27000 | 700 | 59000 |
| 8-10 | | <50 | 150 | <50 | <50 |
| 8-15 | | <50 | 1200 | <50 | <50 |
| 8-20 | | 2500 | 2700 | <50 | <50 |
| 9-10 | | 170 | 16300 | 490 | 680 |
| 9-15 | | 390 | 9000 | 790 | 8200 |
| 9-20 | | 750 | 61000 | 2800 | 38000 |
| 10-10 | | 10 | 130 | 6.3 | 180 |
| 10-15 | | <50 | 1400 | <50 | 84 |
| 10-20 | | <50 | 630 | <50 | 61 |

## CONTAMINATION INVESTIGATION
ANALYTE CONCENTRATIONS, ug/L

| SITE-DEPTH | VCHL | C12DCE | T12DCE | TCE |
|---|---|---|---|---|
| 11-10 | 35 | 160 | <50 | <5 |
| 11-15 | 140 | 2300 | <50 | <50 |
| 11-20 | <50 | <50 | <50 | <50 |
| 11-25 | <50 | 50 | <50 | <50 |
| 12-10 | <50 | 180 | <50 | 460 |
| 12-15 | <50 | 120 | <50 | 300 |
| 12-20 | <50 | 210 | <50 | 170 |
| 13-10 | 25 | 8100 | 150 | 1900 |
| 13-15 | 290 | 46000 | 830 | 217000 |
| 13-20 | 2500 | 160000 | 9000 | 310000 |
| 14-10 | <500 | <500 | <500 | <500 |
| 14-15 | <500 | 730 | <500 | <500 |
| 14-20 | <500 | 3250 | <500 | <500 |
| 15-10 | <500 | <500 | <500 | <500 |
| 15-15 | <500 | 1400 | <500 | <500 |
| 15-20 | <500 | 2300 | <500 | <500 |
| 16-10 | 230 | 2000 | 110 | 2100 |
| 16-15 | 1100 | 6000 | <50 | 1800 |
| 16-20 | 2900 | 6600 | <50 | 650 |
| 18-10 | <50 | 380 | <50 | <50 |
| 18-15 | 280 | 1800 | 59 | <50 |
| 18-20 | 1330 | 14000 | 180 | <50 |
| 18-25 | 390 | 13000 | 110 | <50 |
| 19-10 | <50 | 460 | <50 | <50 |
| 19-15 | <50 | <50 | <50 | <50 |
| 19-20 | <50 | <50 | <50 | <50 |
| 19-25 | <50 | <50 | <50 | <50 |
| 20-10 | <5 | <5 | <5 | <5 |
| 20-15 | 20 | 11000 | 46 | <5 |
| 20-20 | <5 | 1600 | <5 | <5 |
| 21-10 | <50 | 160 | <50 | <50 |
| 21-15 | <50 | 1362 | <50 | <50 |
| 21-20 | 55 | 7050 | <50 | <50 |
| 21-25 | 122 | 1058 | <50 | <50 |

COMPLEX 34 GROUND WATER
CONTAMINATION INVESTIGATION
ANALYTE CONCENTRATIONS, ug/L

| SITE-DEPTH | | VCHL | C12DCE | T12DCE | TCE |
|---|---|---|---|---|---|
| 25-10 | | <500 | <500 | <500 | <500 |
| 25-15 | | <500 | 3500 | <500 | <500 |
| 25-20 | | <500 | 4500 | <500 | <500 |
| 30-15 | | <5 | 63 | <5 | <5 |
| 30-20 | | 26 | 88 | <5 | 14 |
| 30-25 | | 16 | 100 | <5 | 7.7 |
| 31-15 | | <5 | 62 | <5 | <5 |
| 31-20 | | | | | |
| 31-25 | | | | | |
| 32-15 | | <5 | 65 | <5 | <5 |
| 32-20 | | | | | |
| 33-15 | | 19 | 360 | 15 | -- |
| 33-20 | | | | | |
| 33-25 | | | | | |
| WELL 1 (11ft) | | 5.3 | 93 | <5 | <5 |
| WELL 2 (11ft) | | 9.6 | 97 | <5 | <5 |
| WELL 3 (11ft) | | 8.4 | 90 | <5 | <5 |
| 34-10 | | <50 | 69 | <50 | <50 |
| 34-15 | FS | <50 | 268 | <50 | <50 |
| 34-20 | FS | <50 | 481 | <50 | <50 |
| 34-25 | | <50 | 289 | <50 | <50 |
| 35-10 | | <50 | 270 | <50 | <50 |
| 35-15 | | <50 | 240 | <50 | <50 |
| 35-20 | | <50 | 150 | <50 | <50 |
| 35-25 | FS | <50 | <50 | <50 | <50 |
| 40-10 | | <50 | <50 | <50 | <50 |
| 41-10 | | <50 | 1374 | <50 | <50 |
| 41-15 | | <50 | 3470 | <50 | <50 |
| 41-20 | | 80 | 3370 | 54 | <50 |
| 41-25 | | <50 | 59 | <50 | <50 |

COMPLEX 34 GROUND WATER
CONTAMINATION INVESTIGATION
ANALYTE CONCENTRATIONS, ug/L

| SITE-DEPTH | VCHL | C12DCE | T12DCE | TCE |
|---|---|---|---|---|
| 42-15 | <50 | <50 | <50 | <50 |
| 42-20 | <50 | <50 | <50 | <50 |
| 42-25 | <50 | <50 | <50 | <50 |
| 43-15 | 400 | 5200 | 100 | <50 |
| 43-20 | 100 | 1100 | <50 | <50 |
| 43-25 | <50 | <50 | <50 | <50 |
| 44-10 | <5 | <5 | <5 | <5 |
| 44-15 | <5 | <5 | <5 | <5 |
| 44-20 | <5 | <5 | <5 | <5 |
| 44-25 | <5 | <5 | <5 | <5 |
| 45-10 | <5 | <5 | <5 | <5 |
| 45-15 | <5 | <5 | <5 | <5 |
| 45-20 | <5 | <5 | <5 | <5 |
| 45-25 | <5 | <5 | <5 | <5 |
| 46-10 | <5 | <5 | <5 | <5 |
| 46-15 | <5 | <5 | <5 | <5 |
| 46-20 | <5 | <5 | <5 | <5 |
| 46-25 | <5 | <5 | <5 | <5 |
| 47-10 | <5 | <5 | <5 | <5 |
| 47-15 | <5 | 79 | <5 | <5 |
| 47-20 | 58 | <5 | <5 | <5 |
| 47-25 | <5 | <5 | <5 | <5 |
| 48-15 | <5 | <5 | <5 | <5 |
| 48-20 | <5 | <5 | <5 | <5 |
| 48-25 | <5 | <5 | <5 | <5 |
| 49-10 | <5 | <5 | <5 | <5 |
| 49-15 | <5 | 77 | <5 | <5 |
| 49-20 | <5 | 56 | <5 | <5 |
| 49-25 | <5 | <5 | <5 | <5 |
| Primary DWS | 1 | 70 | 100 | 3 |
| TCLP Limit | 200 | -- | -- | 500 |

"VCHL=Vinyl chloride; C12DCE=cis-1,2-Dichloroethene;"

"T12DCE = trans-1,2-Dichloroethene; TCE = Trichloroethylene"

* Other parameters detected.

Depth in feet

increases to 16,300 ppb, at 15 to 20 feet BLS the levels exceed 310,000 ppb, and at 25 feet the levels of VOC's begins to drop off to 24,000 ppb.

A ground water contour map and site map are provided as figures 2 and 3 respectively. The site map shows both the extent of the VOC contamination and the direction of the ground water flow. Both maps indicate a southeasterly ground water flow and contaminant migration direction.

A third area of contamination was also found located to the southwest of the complex. Although contaminants found here are similar in nature to the other two areas. This plume is believed to have been caused by sources other then those located on LCX 34.

## SUMMARY

Numerous areas of environmental concern were identified at LCX-34 during the records search, interviews, and site reconnaissance efforts. Potential contaminants at the site include hydrocarbon fuels, waste oils, PCBs, and solvents. A three week field screening investigation revealed a 421 acre ground water contamination plume extending downward to approximately 30 feet BLS, with VOC contamination levels ranges from 7,800 ppb to 310,000 ppb. Cost estimates for future monitor well installation, and additional EPA site approved investigations can now be developed.

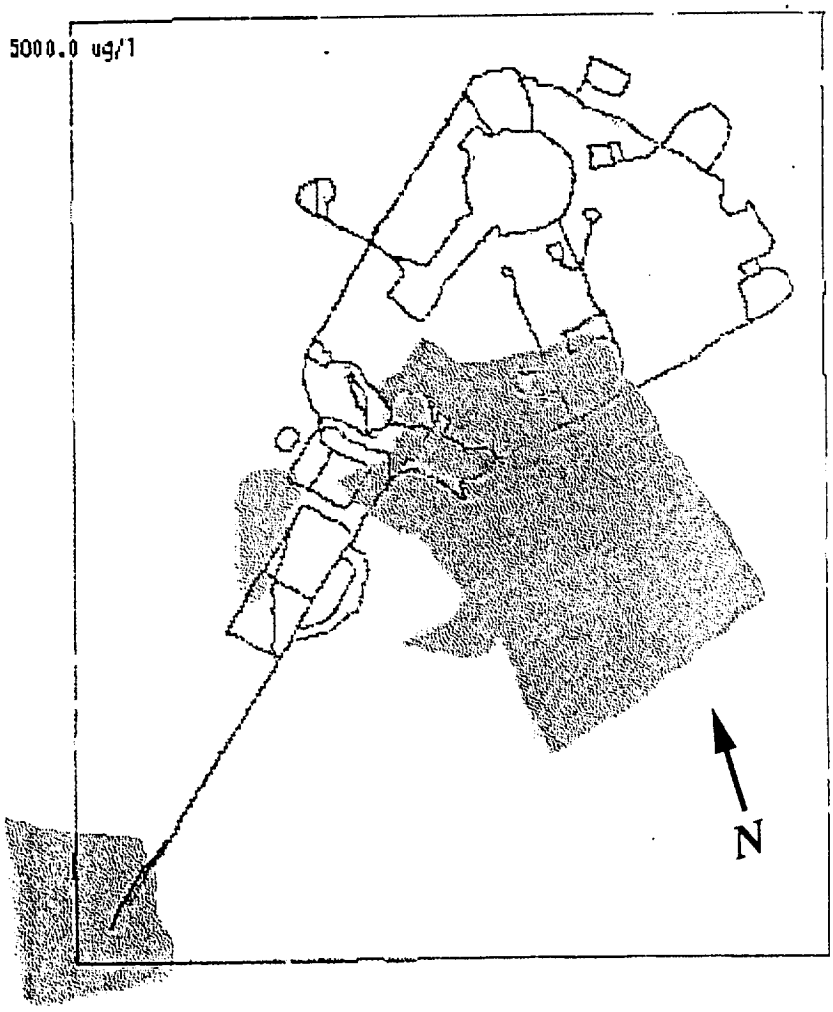
Additionally, as this is an operational area, worker health and safety was evaluated. This study indicated that there is no risk to site workers from this ground water contamination. Several presentations were made to these workers explaining the results of this investigation.

## REFERENCES

U. S. Air Force (AF SPACE COM), 1992. Installation Restoration Program Preliminary Assessment Report for Eastern Space and Missile Center, Patrick Air Force Base.

CIS 1,2 Plume

Concentration Value= 5000.0 ug/l




SITE MAP AND PLUME EXTENT LCX 34 10/93

FIGURE 3